§15. Observation of Poloidal Flow along the Magnetic Flux Surface inside the Magnetic Island in the Large Helical Device

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The Large Helical Device (LHD) has n/m=1/1 external perturbation coils and the size of magnetic island can be controlled up to 10cm by changing the current of the perturbation coils. The radial profiles of poloidal flow velocity and the radial electric field (E_r) is measured with charge exchange spectroscopy (CXS) at the mid plane in LHD with using a charge exchange reaction between fully ionized Neon impurity and atomic hydrogen of neutral beam. The spatial resolution of the measurements of charge exchange spectroscopy is determined by the length of integration of the signal along the line of sight within the beam width of the neutral beam. The spatial resolution near the plasma edge is 1.5cm at the R=4.05m.

When the current of n/m=1/1 external perturbation coils is small (see 260A in Fig.1), no island structure appears in the profile of poloidal flow as well as ion temperature. As the perturbation coil current increases, clear structure of magnetic island appears in the poloidal flow. Widths of island are estimated from the radial profiles of ion temperature and poloidal flow measured. The width is given by the best fit of the measured profiles to the best fit to the model profiles, where the ion temperature is flat and poloidal flow is zero inside the magnetic island. As the perturbation coil current increases, the width of magnetic island estimated from the radial profiles of poloidal flow also increases up to 9 cm, which corresponds to 17 % of the averaged minor radius. When the current of n/m=1/1 external perturbation coils, $I_{n/m=1/1}$, becomes large enough (see 1200A in Fig.1), the poloidal flow along the magnetic flux surface appears inside the magnetic island. It should be noted that the poloidal flow is zero at the center of magnetic island and direction of poloidal flow is reversed across the center of island.

In general the flattening of ion temperature and damping of poloidal flow and flattening of space potential are observed inside the magnetic island. The damping of poloidal flow causes the shared poloidal flow (and radial electric field shear) at the boundary of magnetic island. However, when the magnetic island width exceeds the critical value (15-20 %) of minor radius, the convective poloidal flow in the direction to reduce the poloidal flow shear at the boundary of magnetic island is observed. Therefore, the direction of flow along magnetic flux surface inside the magnetic island and the curvature of space potential changes depending on the edge radial electric field (in the electron root or the ion root[1]) as seen in Fig.2,

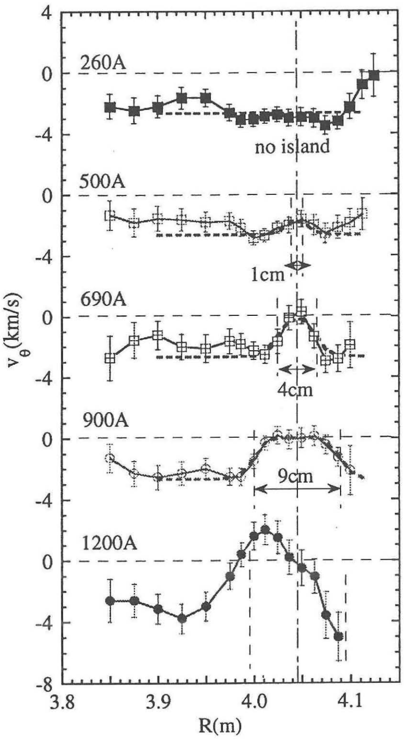

Fig.1. Radial profiles of poloidal rotation velocity, v_θ, for various current of n/m=1/1 external perturbation coils, in the plasma with B = 1.5T and R_{ax} = 3.5m.

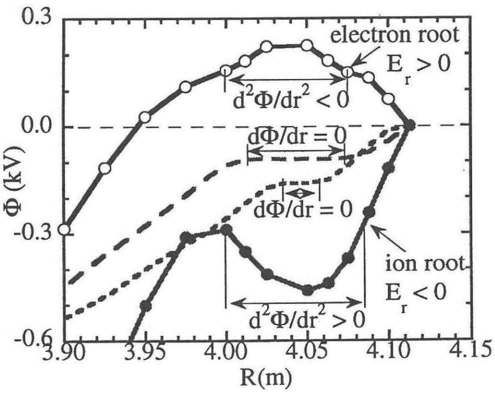

Fig.2 Space potential for the plasmas with (solid lines) and without (dashed lines) flow along magnetic flux surface inside the magnetic island for the plasma in the ion root and electron root.

[1] K.Ida et al., Phys. Rev. Lett., 86, (2001) 5297.